EXTERNAL SEX CHARACTERS OF HARRIS' HAWKS IN WINTER

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Abstract

From 585 individual Harris' Hawk (*Parabuteo unicinctus harrisi*) banded in winter in Texas, plus 3 recoveries and 4 found dead, we conclude that, although there are no apparent plumage differences between males and females, there are practicable sex criteria based on body size. Males take a U.S. Fish and Wildlife Service band size 7a, females 7b (discrepancy, 1.8%). Males fit into holding tubes of 106 mm inside diameter, females 128 mm (about 2% discrepancy). Sexing by weight and wing measurement is most accurate when birds are segregated according to age. There was no overlap in weights in the younger age classes and only 0.3% among adults. Wing chord overlapped by 0.5 to 2.0% and flattened wing by 0 to 1.3%, depending upon age. By combining several criteria, one can be virtually certain about sex diagnosis.

Nineteen *P. u. harrisi* from Tamaulipas agreed with the Texas material; 32 *P. u. superior* from Sonora showed no overlap in weight or in either wing measurement.

Ten birds from Texas, one from Tamaulipas, and two from Sonora showed possible anomalies in molt or pattern of the outer two primaries that confused aging. There was also a suggestion that fully adult primaries might not be attained until the second year.

Introduction

That the males of most falconiforms are smaller than the females is hardly news—but how much smaller? How much overlap? Is the proportion the same among juveniles? Is the difference precise enough to serve as a useful sex character? We examined these questions in Harris' Hawks that we banded in recent years. The last question is particularly important because both sexes have similar, if not identical, plumage.

Methods

We banded Harris' Hawks during short periods in the autumn of 1965 and the winters of 1969–1971, and more intensively in the winters of 1973–1976: *harrisi* in south Texas (593), trans-Pecos Texas (5), Tamaulipas (20); and *superior* (34) in Sonora, for a total of 652. In addition we have weights and/or measurements from 3 birds retrapped in subsequent winters plus one autumn and 4 winter road kills, all from south Texas. Most of our data therefore come from live-caught birds rather than from internally sexed specimens.

Some selection of data has been necessary. Since the subspecies *superior* is larger than *harrisi* (Brown and Amadon 1968), we have not lumped them. In dealing with weights and measurements we have excluded autumn birds (14) and treated the birds from Tamaulipas separately, in order to have a uniform sample of 592 winter birds from Texas. Hawks were processed in the field, sometimes under difficult conditions.

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As a result, a few data were omitted or discarded, and the number of birds in each category may not agree with the others or with the total banded.

In analyzing weights and measurements, it became clear that age was a complicating factor. Northern raptors have a well-defined and relatively short breeding season with correspondingly predictable timing of molt and growth. Within age and sex classes, individuals in winter do not differ widely. Not so the Harris' Hawk. We suspect that, despite a major breeding season in summer, there are a few breeding in every month of the year. During each of the 7 months for which we have data—September, October, December through early April—we have found birds in completely immature, intermediate, and adult plumage. Thus immatures may reach adulthood at any month of the year, and winter populations run the gamut of age classes.

Juvenal and adult plumages are distinctively different (fig. 1). We recognize three age classes: immatures, recorded as Im—those in which all primaries, secondaries, and rectrices are juvenal even though the body molt may have started (generally only a few feathers); immature molting to adult, as Im-Ad, in which wing and/or tail molt has begun; and adult, as Ad, recognizable by the absence of juvenal flight and tail feathers and the presence of one or more generations of adult feathers.

The Im-Ad's are further divided according to the extent of primary molt. Length of chord and of flattened wing is determined by primaries 6 and 7, whose tips project the farthest. Adult primaries are longer than juvenal. Birds whose immature primaries have not yet molted as far as number 7 are recorded as Im-Ad with immature LP_7 (we measure the left wing). Those whose molt has proceeded farther are Im-Ad with adult LP_7. Age classification is thus based on wing and tail feathers only. Our method of recording molt has been described elsewhere (Hamerstrom, F. and F. 1971).

We have used four presumed sex characters. The common (though not absolute) agreement among them plus the shapes of the curves (i.e., bimodal distribution with little overlap) of weights and measurements lead us to believe that the criteria are valid and can be used to define simple and practicable means of sexing Harris' Hawks in the field.

The four sex criteria are: tube size (diameter of the tubes in which we hold the hawks during processing), band size, weight, and wing measurements, both flattened and chord. In the following discussion, each criterion is compared with the *combination*—always a clear majority—of the other criteria. We assume that the true sex is shown by the combination and that disagreement indicates an inadequacy in the criterion under test.

Results

Tube Size. Upon removing a hawk from a trap, we put it into a holding tube devised by the Cedar Grove Ornithological Station. The upper half of such a tube is made of a metal can with both top and bottom removed. The lower half is an identical can with only the top cut out and with breathing holes punched about ¼ in. apart around the outer edge of the bottom. The two cans taped together make one tube. Diurnal raptors thus held are in a darkened place with gentle but firm restraint. They remain quiet, are able to defecate, and come out with feathers undamaged even after some hours.

When we started banding Harris' Hawks, we learned that tube size was a quick first indication of sex, and a good one. Among our collection of holding tubes were

two sizes into which Harris' Hawks fitted nicely, males into tubes made of 46-oz. juice cans measuring 4 3/16 in. (106 mm) inside diameter, females into tubes made of 2-lb. coffee cans 5 1/16 in. (128 mm) diameter. We recorded the size of tube for each of 334 catches from 1974 to 1976. Eleven (3.3%) were in off-size tubes. Seven adults among 173 males were weighed in female tubes. In an unknown but high proportion of cases, however, this happened because all the male tubes already had birds in them. Three of 161 females were weighed in male tubes. One of these was an immature female recorded as 944 g, probably an error; 2 were at the low end of the scale for females (an 802 g immature and an 811 g Im-Ad) and show genuine overlap.

Thus, although our tube-size sample is smaller than those for the other criteria, and the degree of reliability cannot be as exactly stated, it is plainly useful. An unusually large adult male might fit into either a male or a female tube, and a very small immature or Im-Ad female—or an underweight bird—might fit as well in a male tube. Our data suggest, however, that such instances would be very few, on the order of 2%. Further data from banding, weighing and measuring would clarify this point.

We have no record of individual tube sizes for the 20 hawks banded in Tamaulipas, but 13 males and 10 females in Sonora were all in tubes of the appropriate size.

Band Size. Females have stouter tarsometatarsi than males. We took no direct measurements, but the size of the band that fits properly clearly shows the difference. We used standard U.S. Fish and Wildlife Service bands of both butt-end and lock-on type; 7a for males and 7b for females. Of 326 male and 288 female *harrisi* banded in Texas and Tamaulipas, only 11 (1.8%) took the "wrong" size. Four males were banded with 7b's and 7 females with 7a's. The discrepancies seem not to be correlated with age: 2 males were adult, one was Im-Ad with immature LP_7, and one was immature; 2 females were adult, one was Im-Ad with immature LP_7, 3 were immature, and one was age unknown.

In our small sample of 19 males and 14 females of *superior*, one adult female (3.0%) took a 7a.

Excluded from the discussion above are two birds with broken and healed legs, each of which took a larger than normal band because of enlarged tarsi.

Weight. All weights were taken on a double-beam balance. Birds were generally weighed in the tubes already described; a nylon stocking made a good emergency substitute.

Most crops were empty. If not, we estimated the weight of the crop contents and from time to time forced the crop contents up and weighed them as a check on our estimates. We deducted crop contents in excess of an estimated 10 g from gross weights.

Weights are summarized in table 1 and figure 2. Males averaged about 300 g less than females in all three age classes. Mader (1975) found the same relationship for *superior* in Arizona. In Texas adults (N = 397), the weight curves approach bell shape for each sex. Females in both younger age classes show a flatter and broader distribution, perhaps reflecting incomplete growth. Immature male weights show a bell-shaped curve, but both male and female Im-Ad's show a puzzling second peak near the heavy extreme of their curves.

As might be expected, each successive age class averaged heavier than the younger

one, thus precluding a lumping of classes. This progression showed even when the Im-Ad's were divided on the basis of wing development. Those with juvenal primaries through the seventh averaged lighter in weight, in both sexes, than those somewhat older birds whose molt had progressed further. We cannot say when maximum weight is reached, but it appears to be close to, or after, the primaries have fully molted into adult plumage.

There was no overlap in the weights of male and female immatures and Im-Ad's (tables 1, 2, and 3, fig. 2). One adult male exceeded the minimum of adult females by 4 g; the overlap is 0.3%.

The weights of 19 *harrisi* from Tamaulipas did not differ greatly from the weights of the Texas birds (table 2).

The Sonoran birds (*superior*, table 3) fell mostly within the ranges of the Texas birds, although the minima were always greater, and one adult female exceeded the Texas maximum by 6 g. Except for adult males, averages for other age classes of *superior* were higher than for *harrisi*, although the age-group sample sizes are so small as to weaken the comparison. Mader (1975) did not separate age groups in his data for *superior* in Arizona. In table 3 we have combined our Sonoran age classes and entered Mader's values for comparison.

Mader (1975) found no overlap between males and females in his Arizona weights, nor did we in Sonora. We suspect, however, that a larger sample from Sonora would at least narrow the gap.

Table 1. Weights (in grams)—Texas, Winter[1]

	Male			Female		
	No.	Range	Av.	No.	Range	Av.
Immature	37	536-755	636.8	39	789-1137	935.1
Im-Ad						
All	46	581-756	652.8	58	811-1123	963.2
Im LP_7	35	607-730	648.6	45	811-1123	950.3
Ad LP_7	11	581-756	667.4	13	875-1120	1007.8
Adult	220	550-829	689.7	177	825-1173	997.7
Total	303	536-829		274	789-1173	

[1]In this table and all those following, Im = immature, Ad = adult, LP_7 = 7th primary of left wing. Im LP_7 = LP_7 is immature (juvenal), Ad LP_7 = LP_7 is adult.

Table 2. Weights (in grams)—Tamaulipas, Winter

	Male			Female		
	No.	Range	Av.	No.	Range	Av.
Immature	0			0		
Im-Ad	4	598-682	646.2	2	868-942	905.0
Adult	9	647-722	669.0	4	940-1066	992.5
Total	13	598-722		6	868-942	

Table 3. Weights (in grams)—Sonora, Winter

	Male			Female		
	No.	Range	Av.	No.	Range	Av.
Immature	3	652-752	717.3	3	959-1055	1017.0
Im-Ad	2	725-745	735.0	1	985	985
Adult	13	621-758	687.8	10	955-1179	1039.0
Total	18	621-758	697.9	14	955-1179	1030.4
Arizona[a]	37	634-877	725	14	918-1203	1047

[a]Mader (1975)

Wing chord. We routinely held the left wing, bent at the wrist, along a meter stick to measure the chord. Data for the Texas birds are given in table 4 and figure 3.

Slight overlap occurred in all age classes except Im-Ad's with immature LP_7. Among immatures, one female (1.3%) was 3 mm less than the male maximum of 330 mm. Two males (2.0%) equalled or exceeded by 5 mm the female minimum of 326 mm for all Im-Ad's together; when this class was subdivided, there was no overlap among those with immature LP_7, but one male (4.2%) equalled the female minimum of 331 mm in Im-Ad's with adult LP_7. Among adults, 2 males (0.5%) equalled or exceeded by 2 mm the female minimum of 340 mm. The largest discrepancy (4.2%) is in the smallest sample; the rest are small enough to show that chord measurement is a good, though not infallible, sex criterion.

When the Im-Ad's with immature LP_7 are plotted with the immatures (fig. 4), the curves for both sexes are smoothed, and the averages changed by only 0.1 mm for males and 0.8 mm for females. There is no pronounced shift toward the right (longer wing) side of the curve, and the averages for the two groups separately are nearly the same. Adding the few Im-Ad's with adult LP_7 to the adults (fig. 4) makes little change in averages, probably because of the great discrepancy in sample size, but does shift both curves slightly to the left. One could expect such a shift in weights, but since the primaries stop growing once they are hard-penned, this suggests that full development of the adult primaries might not occur until the second year. The Im-Ad's with adult LP_7 do in fact fall between immatures and adults in average chord measurement in both sexes, but especially in females (table 4).

Chord measurements from Tamaulipas are given in table 5. Such differences as there are, compared with Texas birds, are probably due to the small sample size. However, one adult male exceeded the Texas maximum by 3 mm.

Sonoran chord measurements paralleled weights: one adult female exceeded the Texas maximum by 2 mm, the others fell within the Texas ranges but had higher minima and averages. A comparison with Mader's (1975) Arizona values is shown in table 6. The Arizona values are somewhat higher than the Sonoran.

Mader (1975) found no overlap in measurements of the chord in Arizona, nor did we in Sonoran birds whether age classes are lumped or separated.

Flattened Wing. After measuring the chord, the tip of the wing was held firmly on the end of the meter stick, and the folded wing pressed down against it to measure the flattened wing. With the obvious difficulties there are in getting a good measure-

Table 4. Wing chord (in mm)—Texas, Winter

	Males			Females		
	No.	Range	Av.	No.	Range	Av.
Immature	37	299-330	311.7	38	327-367	348.3
Im-Ad						
All	45	298-331	314.0	55	326-368	348.0
Im LP_7	34	298-324	311.9	42	326-360	346.8
Ad LP_7	11	309-331	320.7	13	331-368	352.0
Adult	221	303-342	324.0	176	340-383	360.9
Total	303	298-342		269	326-383	

Table 5. Wing chord (in mm)—Tamaulipas, Winter

	Male			Female		
	No.	Range	Av.	No.	Range	Av.
Immature	0			0		
Im-Ad	4	305-325	317.3	2	338-359	348.5
Adult	8	315-345	326.1	4	347-365	358.0
Total	12	305-345		6	338-365	

Table 6. Wing chord (in mm)—Sonora, Winter

	Male			Female		
	No.	Range	Av.	No.	Range	Av.
Immature	3	318-319	318.3	3	352-363	358.7
Im-Ad	2	321-323	322.0	1	354	354
Adult	13	323-347	333.0	10	353-385	372.6
Total	18	318-347	329.3	14	352-385	368.3
Arizona[a]	37	318-360	335	14	362-385	375

[a]Mader (1975)

ment of the chord of a live and strong bird, we thought that the flattened-wing measurement would give more consistent results. To the extent that the measurement shows somewhat less overlap than the chord, that was true (table 7), but the resulting curves (fig. 5) are not always smoother.

As with the chord, immatures and Im-Ad's with immature LP_7 were virtually the same within sexes, adults showed the longest measurements, and Im-Ad's with adult LP_7 fell between: they were longer than immature wings but not as long as full adults.

There was little overlap between the sexes within age groups—none among adults (although the gap is only 1 mm) or among Im-Ad's with either adult or immature LP_7. When the Im-Ad's are not separated, one female (1.0%) was 1 mm less than the

male maximum. One immature female (1.3%) was 5 mm less than the male maximum. Flattened-wing measurement is thus also a good sex criterion—slightly better than chord but not as good as winter weight.

Measurements of flattened wing from Tamaulipas and Sonora are given in tables 8 and 9. Measurements from each state follow the pattern set by the chord. Mader (1975) did not measure flattened wings, so no comparison with Arizona *superior* is possible.

Table 7. Flattened wing (in mm)—Texas, Winter

	Males			Females		
	No.	Range	Av.	No.	Range	Av.
Immature	37	307-340	320.7	38	335-380	360.3
Im-Ad						
All	45	308-339	323.0	57	338-381	359.8
Im LP_7	34	308-334	320.8	44	338-371	358.2
Ad LP_7	11	314-339	329.7	13	344-381	365.3
Adult	221	313-350	333.2	176	351-397	373.6
Total	303	307-350		271	335-397	

Table 8. Flattened wing (in mm)—Tamaulipas, Winter

	Male			Female		
	No.	Range	Av.	No.	Range	Av.
Immature	0			0		
Im-Ad	4	316-334	325.5	2	346-366	356.0
Adult	8	323-349	332.8	4	354-375	368.5
Total	12	316-349		6	346-375	

Table 9. Flattened wing (in mm)—Sonora, Winter

	Male			Female		
	No.	Range	Av.	No.	Range	Av.
Immature	3	327-329	328.3	3	366-379	373.7
Im-Ad	2	330-334	332.0	1	371	371
Adult	13	333-358	343.5	10	370-400	385.9
Total	18	327-358		14	366-400	

Tail Length. There may well be sex-linked differences in tail length in birds in fresh plumage. However, the entire white tip—about 30 mm—may be worn off, and one finds all stages in between. For that reason, we have not used tail length as a sex criterion.

Birds of Uncertain Age. Six males and 4 females from Texas (1.7% of sample), plus one female from Tamaulipas and one male and one female from Sonora, present a

special problem. These birds have white speckling at the base of one or both of the outer primaries, as in the case of juvenal primaries. For the present we are not sure whether these birds are Im-Ad's that have not yet completely molted, adults with retained juvenal primaries, or adults with aberrent primaries. We call them "Im-Ad or Ad-Ad?" and for the present have excluded them from the tables and graphs. If they are adults, as we now suspect, their addition to the group of adults would make little difference to the present values. Averages would be only slightly changed, and the maxima and minima—which determine overlap between measurements of males and females—would not change. If they are Im-Ad's, the addition of ten Texas birds to the sample "Im-Ad with adult LP_7," which now numbers only 24, would be more appreciable. The new sample would then include 17 males and 17 females:

Weight—Males average 677.9 g, range 581–756; females average 986.8 g, range 862–1120. No overlap.

Chord—Males average 322.6 mm, range 309–333; females average 353.9 mm, range 331–370. There would be an increase of 2 mm in the maxima for both males and females (one each); one female (331 mm) would now be less than the males' maximum, or a discrepancy of 2.9% instead of the present 4.2%.

Flattened wing—Males average 331.8 mm, range 314–342; females average 367.0 mm, range 344–381. The males' maximum would be increased by 3 mm, but there would still be no overlap.

Summary and Conclusions

Harris' Hawks do not have sexually distinct plumages but do differ in several body measurements. From our sample of 592 *harrisi* handled in winter in Texas we conclude that four external sex criteria have so little overlap that they are individually reliable within rather small tolerances. Data in the text define the extent of separation or overlap. As a field tool, we suggest that if any 3 of the following 4 criteria agree, sex determination can be considered virtually certain. Known discrepancies (i.e., overlap) in individual criteria, when present, are indicated in parentheses:

1. The bird fits nicely into a tube with interior diameter of 106 mm—male; interior diameter 128 mm—female (about 2%).

2. U.S. Fish and Wildlife Service band 7a fits properly—male; 7b—female (1.8%).

3. Weight (by age classes):

Immature (no adult primaries or rectrices): to 760 g—male; 780 g and more—female.
Im-Ad (immature molting to adult—some primaries or rectrices incoming or adult): to 760 g—male; 800 g and more—female.
Adult (no juvenal or incoming primaries or rectrices): to 829 g—male; 825 g and more—female (0.3%).

Since measurements of chord and flattened wing are so closely related, they are treated as one criterion:

4a. Chord (by age classes):

Immature: to 330 mm—male; 327 mm and more—female (1.3%).
Im-Ad: to 331 mm—male; 326 mm and more—female (2.0%).
Adult: to 342 mm—male; 340 mm and more—female (0.5%).

4b. Flattened wing (by age classes):

Immature: to 340 mm—male; 335 mm and more—female (1.3%).
Im-Ad: to 339 mm—male; 338 mm and more—female (1.0%).

Adult: to 350 mm—male; 351 mm and more—female.

Where there is overlap in one criterion, even though small, it is particularly important to use as many as possible of the other criteria in order to have a clear majority. Age determination is in many cases a prerequisite in interpreting weights and wing measurements.

The 19 *harrisi* from Tamaulipas fit with the Texas material reasonably well, and the Texas criteria would probably also serve winter banders there. The 32 Sonoran *superior,* somewhat larger than *harrisi,* are rather few for establishing clear criteria. It is certainly suggestive that there was, as with Mader's (1975) sample, no overlap in winter weights or chord measurements. Combining the two sets of data, we tentatively suggest 880 g as a maximum for males and 915 g as a minimum for females; among chord measurements, 360 mm or less equals male and 362 mm or more, female.

It is possible that with more data one could use only two age classes—those with immature seventh primary and those with adult seventh primary. At present, the immatures and Im-Ad's with immature seventh primary could be combined, but the present sample of immatures with adult seventh primary is too small to be clearly interpretable. Enlargement of that particular sample would also clarify the possibility that fully adult primaries are not acquired until the second year. These problems, and the uncertainty that still exists concerning the few "Im-Ad or Ad-Ad?" birds, plainly mean "back to the banding grounds."

Acknowledgments

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Figure 1. Wing of Im-Ad (immature molting to adult) Harris' Hawk female illustrating (a) shape of the wing, (b) difference between immature (barred) and adult (dark, virtually unmarked) flight feathers, and (c) that adult primaries and secondaries are longer than immature's. This bird shows the uniformly dark breast of the adult; immatures have dark breasts with conspicuous light streaks.

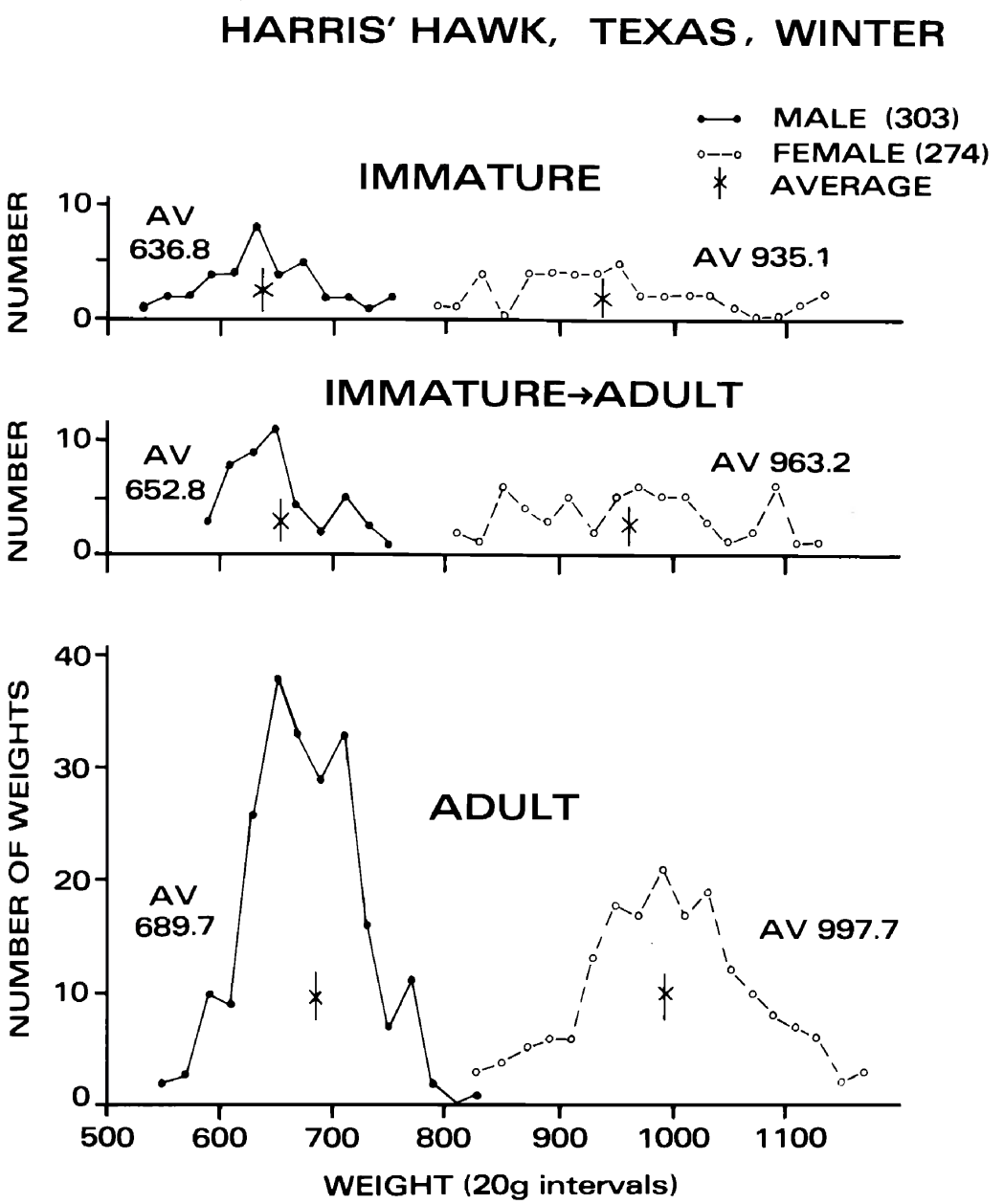

Figure 2. Winter weights of Harris' Hawks banded in Texas. Crop contents in excess of 10 g have been deducted.

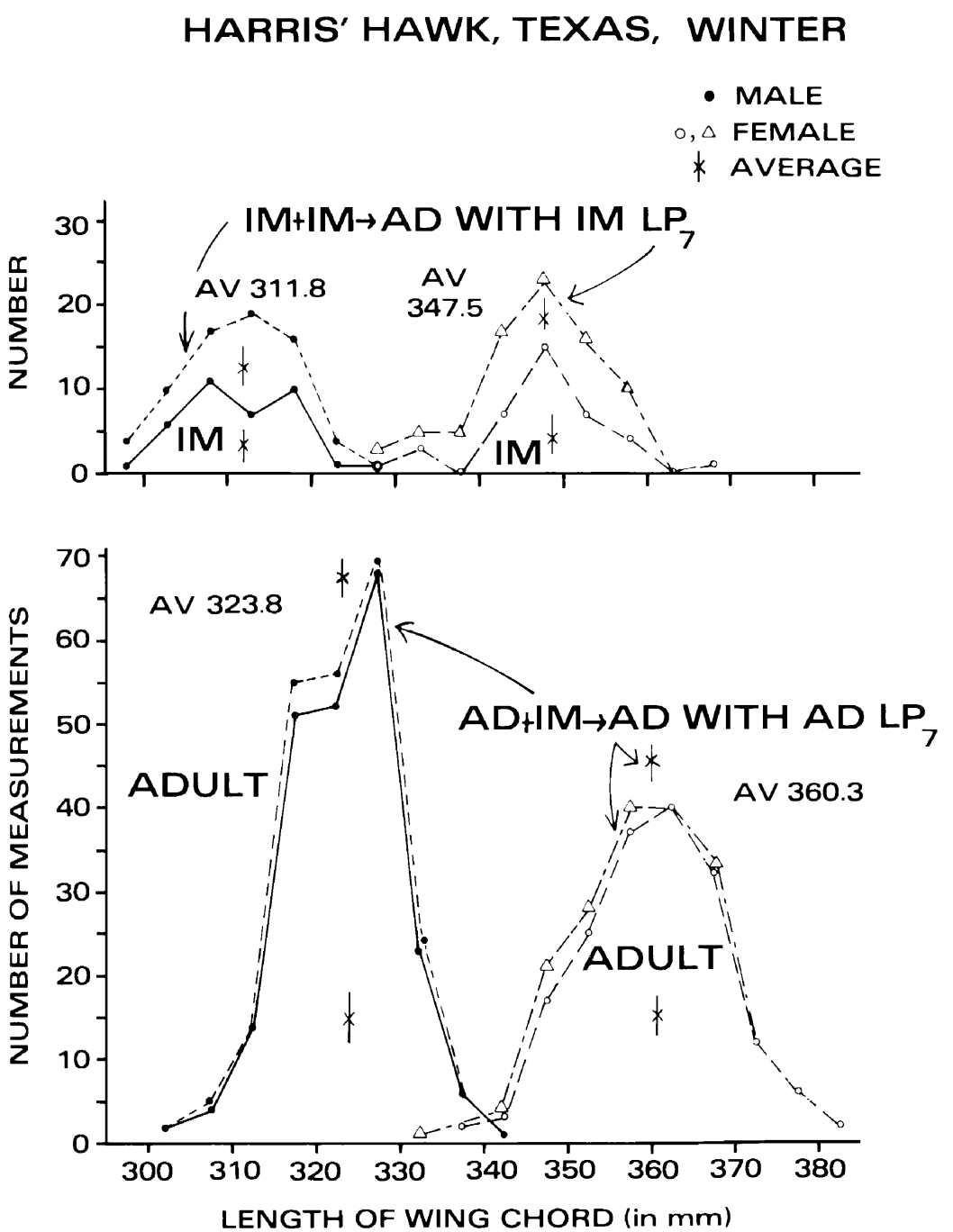

Figure 3. Length of wing chord of winter-banded Texas Harris' Hawks.

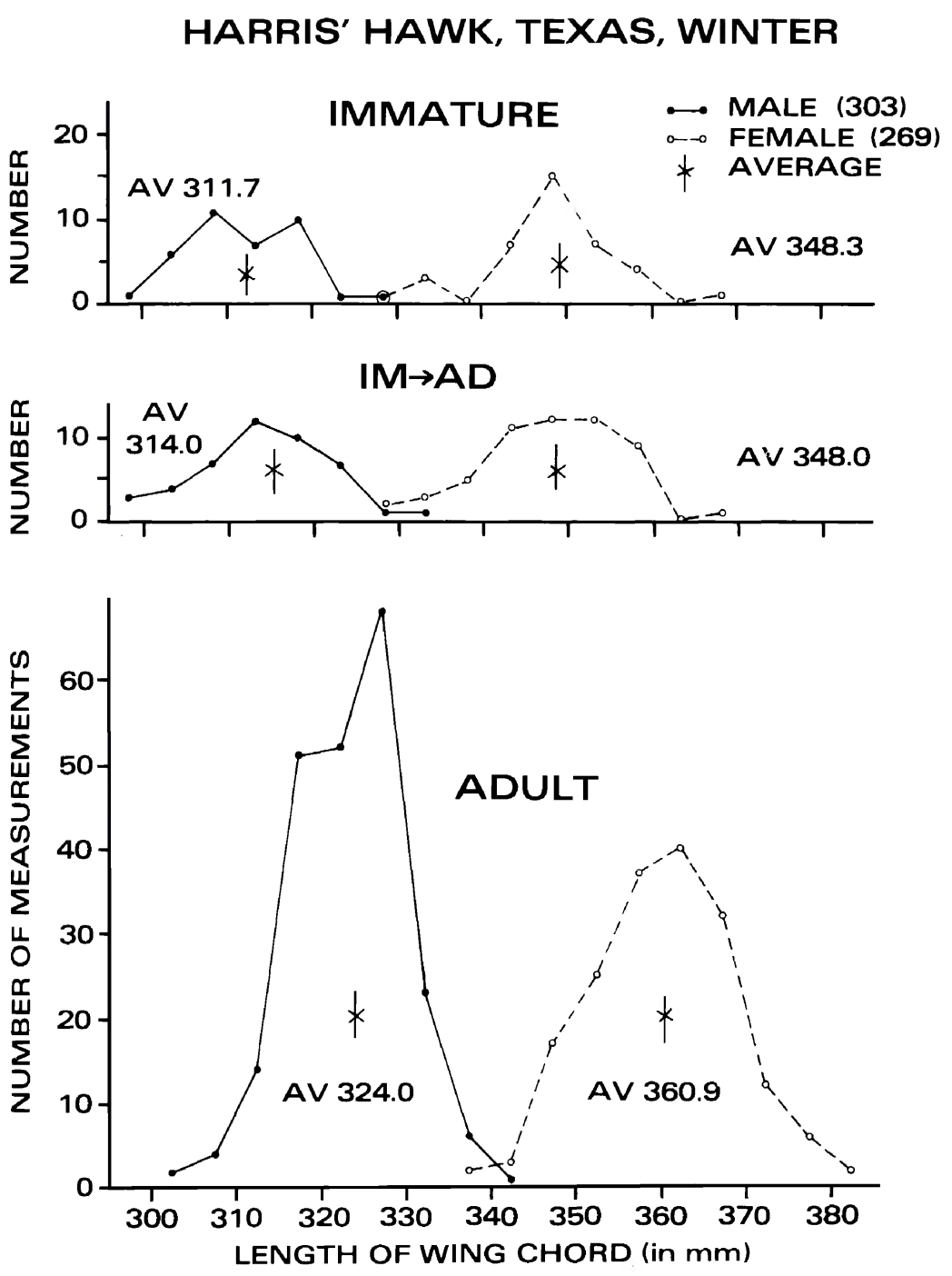

Figure 4. Chord measurements recombined: *Upper*—Immatures alone and immatures plus immatures molting to adult plumage but still with immature seventh primary. *Lower*—Adults alone and adults plus immatures molting to adult plumage, already with adult seventh primary.

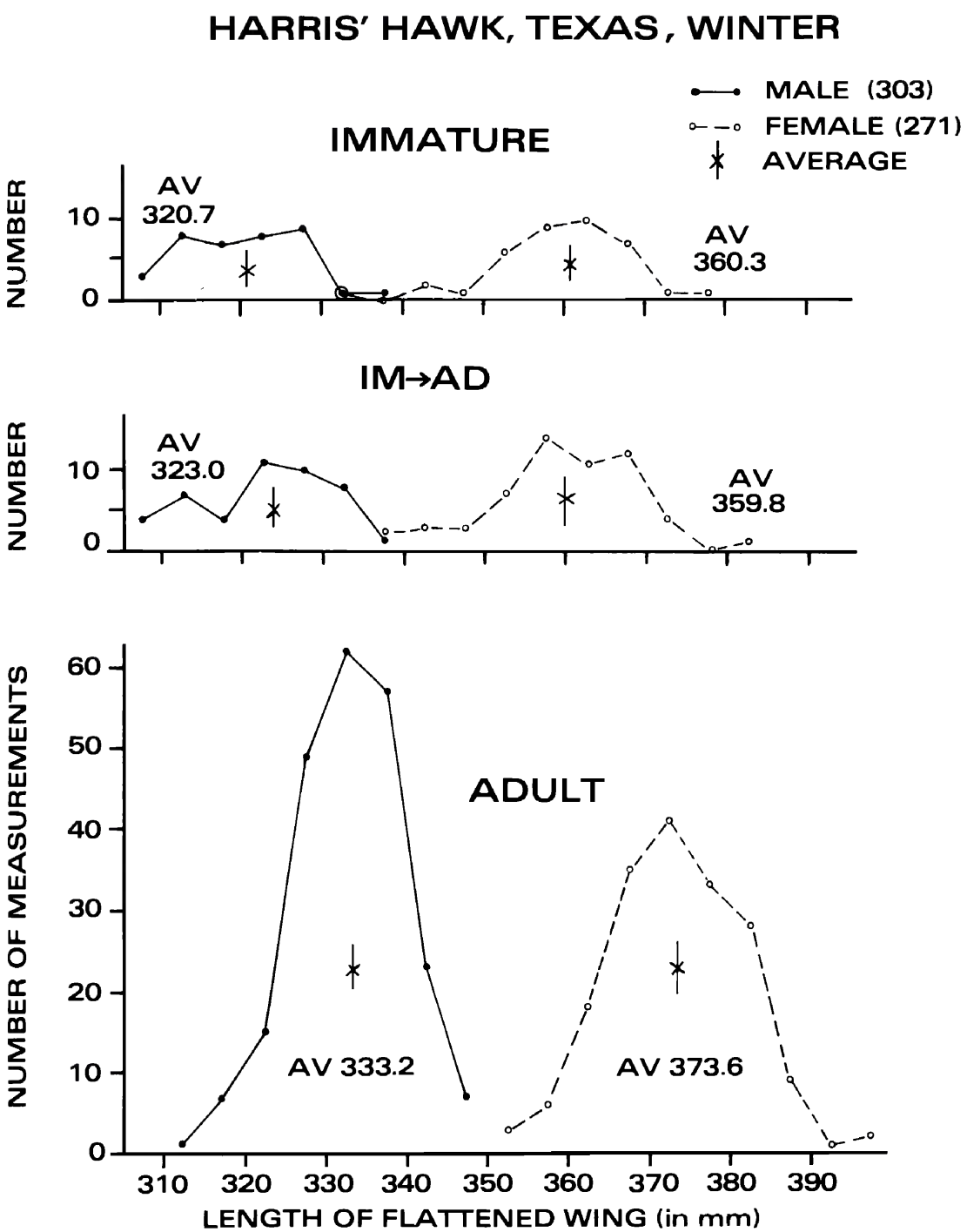

Figure 5. Length of flattened wing of winter-banded Texas Harris' Hawks.